Near-Surface Atmosphere and Surface Wave Influences on Rf/EO Propagation Over the Sea

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LONG-TERM GOALS

Modeling and measurement methods for estimation of over water near-surface atmospheric properties that affect Rf/EO propagation and that are important to weapon system performance.

OBJECTIVES

Overall objective is to improve the turbulent structure and profile descriptions fundamental in near-surface Rf/EO propagation models. Objectives are to:

Obtain near-direct measures of atmospheric properties affecting observed propagation.

Determine how well present dimensionless MO functions describe scalar profiles and turbulent intensities and propagation outcomes over all ranges of stability.

Establish surface waves effects on near-surface scalar profiles and to determine how to relate these to wave age, wave height, wavelength, and directional wave spectra.

APPROACH

Perform field collection and analyses/interpretation of near-surface atmospheric properties and surface waves to relate their impact on near-horizon Rf/EO propagation over the ocean. Field collection with instrumented buoy of mean and fluctuation airflow and surface properties occurs at the Rf/EO mid-path locations. Joint analyses/interpretations are on near-surface refractive gradients, turbulence, and surface wave data obtained with RF/EO propagation. The Rf and EO data collection and analyses/interpretation are related to flux-profile relationships. Propagation phenomena (scintillation, refraction and loss) are related to mean and turbulent air flow and 2-dimensional surface waves. Analyses/interpretations are designed for existing bulk model improvements to account for the wave influence within existing empirical scaling (Monin-Obukhov). There is some guidance from recent numerical modeling.

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14. ABSTRACT
Modeling and measurement methods for estimation of over water near-surface atmospheric properties that affect Rf/EO propagation and that are important to weapon system performance.

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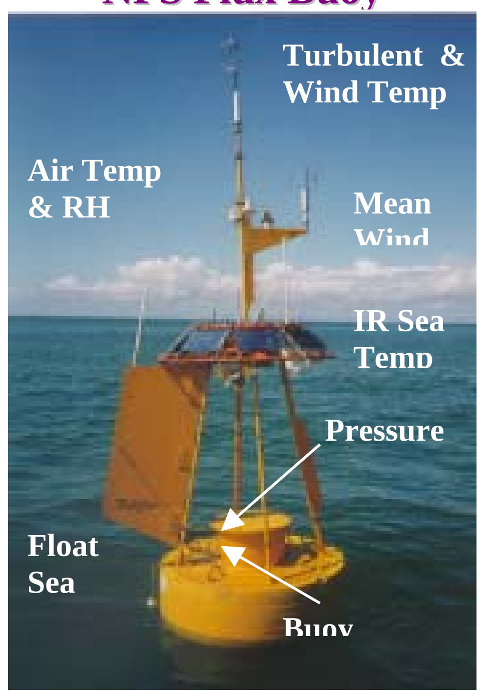
WORK COMPLETED

Work was completed in FY01 with regard to both analyses and field collection. **Analyses and interpretation** of existing data were made on identification and describing differences between observed and bulk predicted atmospheric effects in the current as well as previous years. Collaborative analyses/interpretations of mean airflow properties matched collaborating PIs objectives to evaluate existing propagation models, e.g. IRBLEM. Separate interpretations addressed the use of current bulk methods for estimating optical turbulence (C_n^2) and scaling parameters (T_*, q_*, and u_*). Waves influences were qualitatively identified. More quantitative information on wave influence and on the profiles themselves is being obtained. Flux buoy data obtained off Duck, NC, and Wallops, VA, were examined with regard to fetch-related differences in the bulk transfer coefficients on-shore/off-shore and wind-wave angle difference dependence of the drag coefficient, in addition to turbulent intensity comparisons. **Instrumented Flux-buoy field collections** were made during the Roughness and Evaporation Duct (RED) experiment at the mid-point of the EO path. Continuous collection occurred from to 24 August to 16 September, 2001, with recovery on 18 September. Mean airflow values and status of fast sampled (turbulence and waves) values were received at a shoreline receiver. All systems operated except one component of the buoy motion measurement system failed partway through the collection.

NPS 'Flux' Buoy RED Measurements

Parameter Measured	Existing
Mean Meteorology	X
Temperature Profile	X
Humidity Profile	X
Momentum Flux	X
Buoyancy Flux	X
SST	X
1 & 2-D Wave Spectra	X

NPS Flux Buoy



RESULTS

Results show that current models for turbulent intensity perform well in unstable conditions but clearly not in stable conditions, Frederickson et al 2000. Further San Diego turbulence and scintillation values agree. Stable (T_{air}-T_{sea} > 0) condition errors could be due to the effects of surface waves on near surface profiles, or off-shore advection in a coastal region. Results for stable (T_{air}-T_{sea} > 0) conditions in San Diego Bay (San Diego'98), Figure 1, indicate bulk values overestimate (both C^2_T and C^2_q) and off the east coast (Duck'99 and Wallops'00), Figure 2, the bulk values underestimate (C^2_T) observed turbulent values.

Wave influence's role is evident because the primary difference between the San Diego Bay and East Coast sites that the San Diego Bay is a more swell-dominated regime. Descriptions of the wave influence seem to have become a necessity if near-surface optical turbulence is to be described. Because of the flux-profile relationships, we can assume that existing scaling also does not describe profiles properly over waves, in stable conditions.

Flux buoy data obtained off Duck, NC, and Wallops, VA, have been those most recently examined to determine wave influence on the adjacent airflow. Examinations were made on fetch-related differences in the bulk transfer coefficients on-shore/off-shore and wind-wave angle difference dependence of the drag coefficient.

San Diego Bay

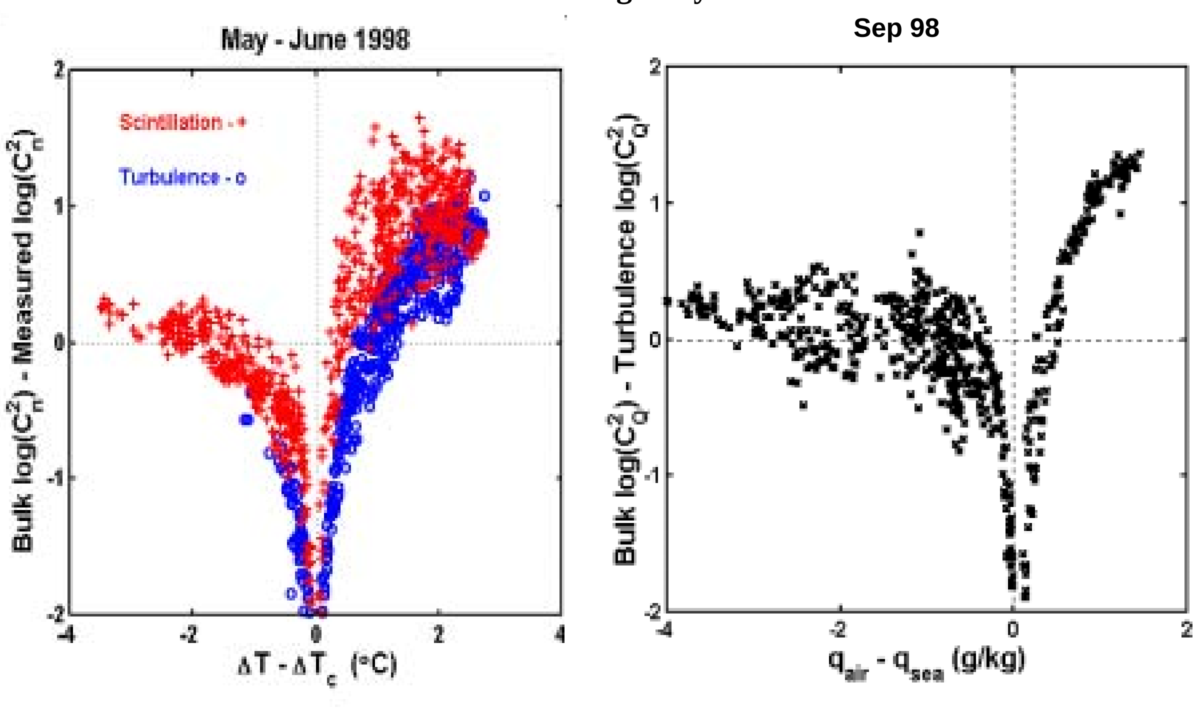


Figure 1

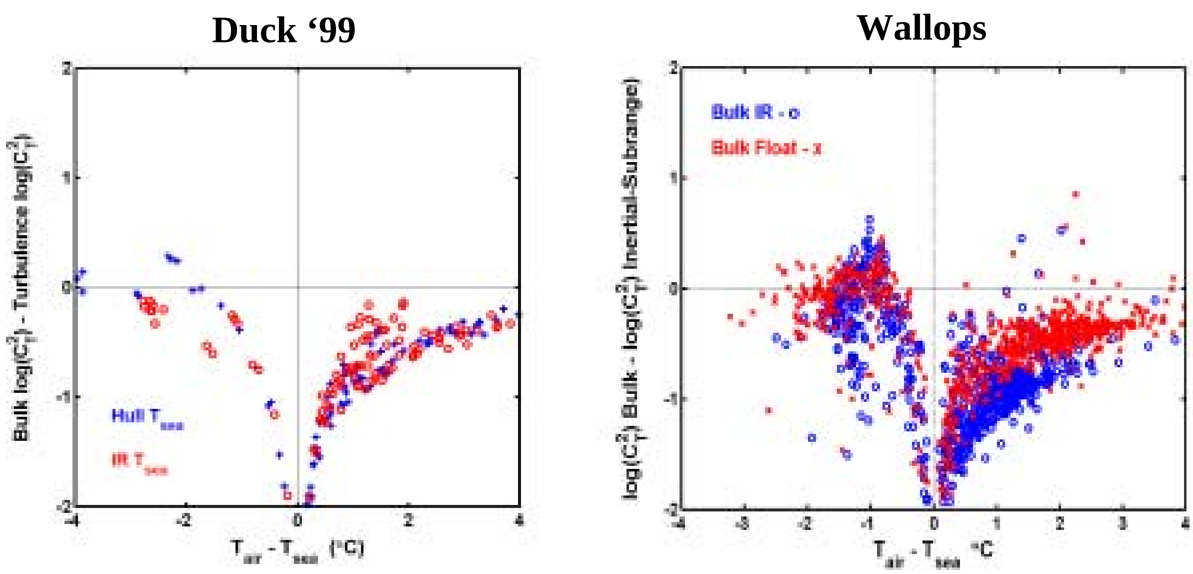


Figure 2

IMPACT/APPLICATIONS:

Understandings achieved from this effort will improve scalar flux-scaling relationships over waves and will enhance ability to use remote sensing of sea-surface temperature and waves in estimating near-surface Rf/EO propagation conditions.

TRANSITIONS

The results are being used to modify/direct application of models and measurements within operational tactical decision aids, e.g. AREPS.

RELATED PROJECTS

Related projects are the SPAWAR PMW-155's 6.4 programs supporting acquisition of shipboard METOC sensors and 6.2-6.4 R&D programs supporting development and validation of METOC models for Rf/EO affecting properties.

SUMMARY

Weapon system performance prediction requires bulk models based on operational type data. Over water, near-surface airflow properties (profiles and turbulence) affecting Rf and EO propagation are inadequately described by bulk models because of unaccounted for wave influences. Results from future work could reduce errors in observed optical turbulence values that are 10 times higher to 50% lower, depending on wind-wave conditions. There will be similar reduction in errors in estimating profile gradient which are known to be large when water is cooler than air.

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PUBLICATIONS

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